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Radiant Glass Heating Panels

IN RECENT YEARS radiant glass heating panels have come into increasing use for heating residences and other small buildings. This type of panel was recently studied under controlled conditions by Paul R. Achenbach of the National Bureau of Standards under the sponsorship of the Housing and Home Finance Agency. The results of the tests indicated that electrically heated radiant glass panels constitute a satisfactory method of warming a basementless house. However, even with the house thoroughly insulated, electric heating can be expected to entail higher annual heating costs in most areas than would coal, oil, or gas, because useful heat derived from electricity has a higher unit cost than that produced from these common fuels.

The tests were conducted in the NBS test bungalow, a small 1-story house of 4 rooms and bath, with a hallway near the middle of the structure connecting the rooms. For the purposes of these tests the house was treated as basementless. The test bungalow is completely enclosed in an insulated structure with a 5-ft space between outside bungalow walls and the inner walls of the enclosure. Unit coolers in the enclosure allow the control of outdoor temperatures. Thermocouples, suspended at various levels throughout the house, were used with indicating and recording equipment to observe the temperature distribution in the house.

The typical radiant glass panel is mounted on a metal frame and backed by a reflective shield from which it is separated by a small air space. A metallic coating on the rear surface of the glass serves as the electric conductor and heating element. The output per panel is typically about 1,000 w although units with lower wattage ratings are available from some manufacturers. Panels are designed for either 115 or 230 v alternating current and are made for mounting beneath windows, as baseboard units, or as vertical units adjacent to window frames.

Heat is transmitted from glass heating panels primarily by radiation and convection. When the panel is heated above the room air temperature, heated air passes upward over the face of the panel, through the space between the glass and the reflective shield, and between the shield and the frame of the panel assembly. At the same time, radiant heat is emitted outward from the face of the panel. The passage of air through the spaces back of the glass keeps the temperature of the rear of the assembly cool enough to allow it to be in contact with combustible materials.

For some of the tests the bungalow was insulated with 3⅝ in. of rock wool laid on the upper side of the ceiling of the living quarters and 1 in. of rigid fiber board insulation nailed to the bottom of the floor joints, and the windows and doors were weatherstripped. The bungalow with this amount of insulation was considered as "uninsulated." For the remainder of the tests, the stud spaces of the walls of the bungalow were filled with expanded-mica insulation, and plastic-filled wire-mesh screen cloth was tacked over the outside of the window frames to simulate storm windows. With this additional insulation the house was considered "insulated."

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Ten radiant glass heating panels were installed in the test bungalow at the beginning of the tests. Two of these were placed under the double window of the living room, 1 under the single window of the living room, and 1 under each of the other windows of the bungalow, making a total of 3 panels in the living room, 2 in the kitchen, 2 in the north bedroom, 2 in the south bedroom, and 1 in the bathroom, all located just above the floor level. The panels were rated at 1,000 w at 230 v but were actually operated on a 208-v power supply corresponding to a capacity of approximately 820 w. The panels in each room were connected to separate electrical circuits and the room temperature of each room was controlled by means of an individual thermostat and relay.

The initial power demand for the panels was about 145 percent of the steady demand after the panels became thoroughly heated. The panels required approximately 20 min after starting to attain steady power demand and approximately 30 min to attain a steady temperature on their exposed glass surfaces. The temperatures at the centers of the glass plates operating at rated voltage averaged about 340° F.

The temperatures observed in the test bungalow for 11 different test conditions with constant outdoor temperatures in the range from 0° to 32° F show that the vertical temperature differences in the living zone (2 to 60 in. above the floor) were moderately low, ranging from 3.5 deg F for an outdoor temperature of 32° F to 7.0 deg F for an outdoor temperature of 0° F. Thus, the temperature gradient in the living zone was 0.7 deg F/ft of height at the higher outdoor temperature and 1.4 deg F/ft of height at the lower outdoor temperature. The average gradient from floor to ceiling was a little lower than in the living zone, ranging from 0.6 deg F/ft for an outdoor temperature of 32° F. to 1.1 deg F/ft for an outdoor temperature of 0° F.

The vertical temperature differences in the living zone with the radiant glass panels were about 1 to 2 deg F greater than those observed in the same house with a baseboard convector heating system. Insulating the walls and adding storm windows did not significantly change the vertical temperature differences observed in this house. Since the same number of panels were in operation in the insulated and uninsulated condition of the house, the percentage of time during which the heaters were energized was appreciably less in the insulated house. Consequently, the chimney effect of the house and natural convection played a more significant role in the insulated house during the longer periods when the heaters were not energized than they did in the uninsulated house.

The average horizontal temperature variation between stations of observation within individual rooms was 1.6 deg F for an outdoor temperature of 32° F and 2.6 deg F for an outdoor temperature of 0° F when the differences at all 5 levels of observation were averaged together for each room. However, the horizontal temperature differences within the rooms were consistently greater at 2 in. and 30 in. above the floor than at the higher levels of observation, since the electric panels were located below the 30-in. level and emitted more radiant heat to some of the thermocouples than to others.

The maximum horizontal temperature difference between rooms was 1.6 deg F for an outdoor temperature of 32° F and 2.5 deg F for an outdoor temperature of 0° F when all levels of observation were considered in computation of the average. The greatest variations between rooms usually occurred at levels 2 in. and 60 in. above the floor. Insulating the walls and adding storm windows did not significantly change the horizontal temperature variations within rooms and between rooms.

The heat loss of the test bungalow was 8.33 kw at an outdoor temperature of 0° F when the walls were uninsulated and 5.18 kw when the walls were insulated.

The recently completed NBS study of radiant glass heating panels indicated that the units were usable as a satisfactory, though more expensive, method of warming a basementless house. In the tests two units were mounted together under the living room window as shown. Installations in the other rooms were of single panels only.

Because the line voltage was only 208 v, the 10 panels installed in the test bungalow consumed only 8.2 kw of electric power; and since the installed capacity did not exactly equal the heat loss on a room-by-room basis, some of the rooms of the uninsulated house were slightly underheated at an outside temperature of 0° F. The relation between heat loss and indoor-outdoor temperature difference was linear. The ratio of the heat loss of the insulated structure to that of the uninsulated structure was 62 percent for an outdoor temperature of 0° F and 66 percent for an outdoor temperature of 32° F.

An attempt was made to heat the insulated house with 6 panels at an outdoor temperature of 0° F, using 2 panels in the living room and 1 each in the other 4 smaller rooms. Some of the rooms were found to be underheated because the heat loss of a particular room exceeded the installed capacity of that room. The results indicated the desirability of having heating units of lower and intermediate wattage capacity to heat small rooms.

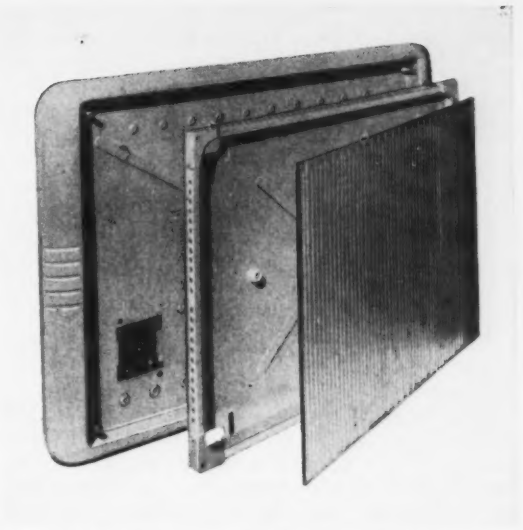
The radiant panels in the uninsulated bungalow were compared under identical conditions with a forced warm-air heating system, using baseboard registers, the vanes of which directed the warm air down at the floor. Comparison showed the radiant system provided more radiant energy at the 30-in. level and more comfort at the floor level.

The effect of lowering and raising the thermostat setting was studied for both temperature pickup and power demands. From the data accumulated it appears that in the insulated house, when all 10 panels are utilized, 1 hr is required to raise the room temperatures from 65° to 70° F at an outside temperature of 0° F.

Analysis of the tests indicated that compensated room thermostats with very low differential that produce rapid cycling of the heating units are desirable with radiant glass heating panels. This would provide a continuous emission of radiant heat since the cessation of radiation between heating cycles was quite noticeable when the "off" period was of long duration. Also a control device for the system, which would permit heating of the house to a comfortable level at design outdoor temperature, but which would limit the electric-power demand to a value approximately equivalent to the design heat-loss rate, is desirable from the standpoint of both the consumer and the utility company.

One type of glass panel was subjected to thermal shock tests of the type that might occur in use, such as rain coming through a window or shower spray in the bathroom. The main effect of the treatment was an increase in power demanded by the panel due to the water's cooling action. Mechanical shock tests showed that the principal weakness was in resistance to shock around the edges.

The results of these tests indicate that electrically heated radiant glass panels constitute a satisfactory method of warming a well insulated basementless house from the standpoint of temperature gradients in the vertical and horizontal directions, floor temperatures, and general comfort. Accepted methods for the calculation of the heat loss of a house may be used in determination of the total capacity of the heating units required. The total energy required to produce a desired condition of warmth may be slightly less with electric panels than with more conventional heating units because of the absence of piping or duct heat losses, because the reverse heat losses from the heating elements are lower, and because the individual room thermostats can more readily prevent overheating of any of the rooms.



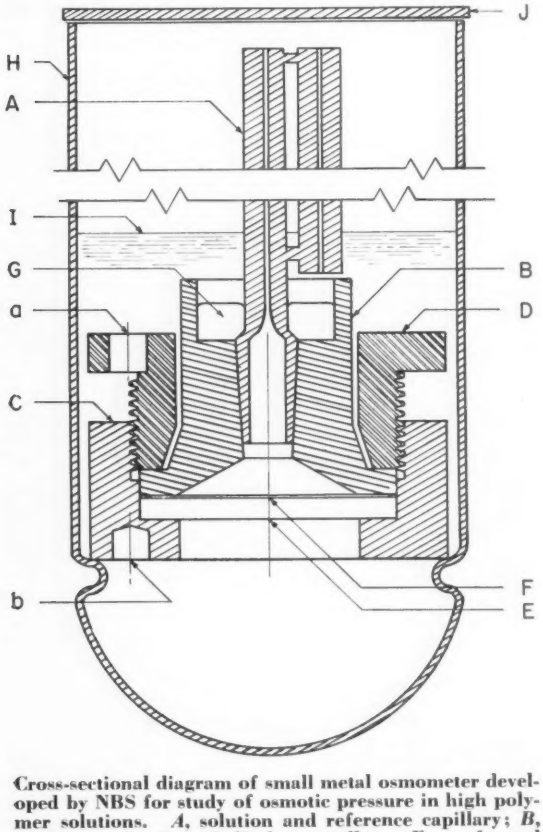
An exploded view of a typical radiant glass heating panel shows its principal components—frame, reflector, and glass heating element. Units like this were installed in the test bungalow for the heating study.

A cutaway view of the insulating shell that surrounds the bungalow shows a corner of the test bungalow. Unit coolers are used to maintain desired test temperatures.

A Simple, Rugged Osmometer

ALTHOUGH glass instruments for measurement of osmotic pressure are relatively easy to make, they are fragile and may require frequent repairs. Small metal osmometers, on the other hand, are much more rugged and can be designed for easy and rapid assembly and simplicity of operation. To replace tediously assembled and easily chipped glass osmometers, G. A. Hanks and S. G. Weissberg of the National Bureau of Standards polymer structure laboratory have developed a simple, rugged osmometer, largely of metal construction, which has several significant advantages over other instruments of this type.

Previously instruments for determination of the osmotic pressure developed by a solution of high polymer have been in some respects too inconvenient to use. The new NBS design is particularly well adapted for use; it permits the instrument to be assembled, rinsed, and filled conveniently while keeping the membrane wet with solvent at all times. The solution cell holds less than 2 ml so that a relatively small quantity of polymer suffices for a complete osmotic pressure curve.



Cross-sectional diagram of small metal osmometer developed by NBS for study of osmotic pressure in high polymer solutions. *A*, solution and reference capillary; *B*, solution cell; *C* and *D*, brass collars; *E*, perforated plate; *F*, semipermeable membrane; *G*, mercury seal; *H*, solvent container; *I*, solvent level; *J*, cover plate; *a*, wrench holes; *b*, holes engaging pins in assembly bath.

The heart of the NBS osmometer, a nickel-plated brass cell, contains the polymer solution of which the osmotic pressure is to be measured. A vertical glass capillary of 0.5-mm bore is inserted in the top of the cell, and a semipermeable membrane is stretched horizontally across an opening in the bottom of the cell. The cell, membrane, and lower portion of the capillary are immersed in the solvent or the polymer solution. The liquid level in the capillary, showing the rise of the polymer solution due to osmotic pressure, is compared with the level of the pure solvent in a reference capillary attached to the measuring capillary by either a metal or a glass bridge.

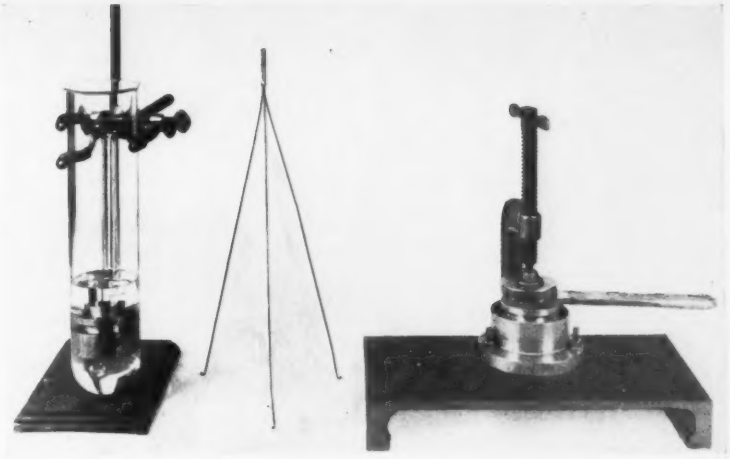
A perforated brass plate holds the semipermeable membrane tightly against the opening in the solution cell. Two brass collars, one of which screws into the other, support the assembly within the solvent container and provide the pressure required to hold the brass plate against the solution cell. The membrane serves as a gasket between the perforated plate and the solution cell.

A male standard taper (10/18) joint sealed to one end of the measuring capillary fits into the metal cell, which has been reamed and ground to accommodate it; and a mercury well assures a leakproof seal. The flat surface of the cell adjacent to the membrane is lathe-finished and lapped on an optical lap to a mirror finish.

For assembly purposes the lower brass collar, which serves as the osmometer base, fits into a solvent well. Vertical dowel pins spaced at 120° intervals in the floor of the well engage holes in the under side of the osmometer base. The base plate of the solvent well is attached to a channel iron that can be clamped to a work bench. The upper brass collar has three holes in its top into which a wrench is inserted for final tightening of the assembly. A three-pronged brass hook, designed so as to fit the three holes in the upper collar, facilitates transfer of the osmometer to and from the tubes that contain the solvent during the test.

In the assembly of the instrument the perforated plate is first fitted ino the osmometer base. Solvent is then poured into the well up to about 0.5 cm above the level of the perforated plate to keep the membrane, which is put in place next, wet with solvent during the assembly period. Next the cell is placed on the membrane. Finally, the brass collars are screwed together.

When the osmometer has been filled with solution, it is placed in a constant-temperature bath. A revolving carriage in which 12 osmometers can be mounted in the bath allows each osmometer to be brought into position for measurements of the meniscus-heights with a cathetometer. Membranes of cellophane, regenerated cellulose, and denitrated collodion have been used successfully in the NBS osmometer.



Left: **The new osmometer developed by the Bureau is shown completely assembled and immersed in a solvent. Osmotic pressure of the solution with the cell is determined from the difference in the liquid levels in the two glass capillaries.** ***Center:*** **Three-pronged brass hook that facilitates transfer of osmometer to and from the tubes that contain the solvent during the test.** ***Right:*** **Osmometer in position for final tightening. The wrench has three ¼-in. pins, which engage three holes in the top of the upper brass collar.**

The NBS osmometer sometimes requires 2 to 3 days for osmotic equilibrium to develop, although this depends primarily on the initial head and permeability of the membrane; and occasional membrane buckling makes it difficult to make dynamic measurements, as is the case with any osmometer that supports the membrane on only one side. However, the NBS osmometer has the advantages of rugged and simple construction; rapid assembly, rinsing, and filling of the cell; minimum possibility of the membrane's drying; and small cell volume (1.2 ml). The membrane can be adequately tightened between the perforated plate and the lapped surface of the cell, especially during use of hydrocarbon solvents, which cause considerable membrane shrinkage. The osmometer design reduces the possibility of entrapment of air in the cell. The complete assembly is small, and a number of osmometers can be used simultaneously for a complete osmotic pressure determination. Also, the design makes it easy to soak the cell in a large volume of solvent to minimize adsorption of polymer.

For further technical details, see A convenient small osmometer, *by G. A. Hanks and S. G. Weissberg, J. Research NBS* **49,** *6 (December 1952), reprinted as NBS Research Paper 2377, obtainable for 5 cents from Superintendent of Documents, Government Printing Office, Washington 25, D. C.*

1953 Technical Session on Bone Char Research

THE THIRD biennial Technical Session on Bone Char Research was held in New Orleans on February 26 and 27. Sponsored jointly by the National Bureau of Standards and the Bone Char Research Project, Inc., the Session was attended by sugar technologists from Belgium, Brazil, Canada, Cuba, England, Scotland, and the Netherlands, as well as the United States. Sixteen technical papers, treating the most recent developments in bone char research and the use of the char in sugar refining, were presented.

Because of the enormous quantities of bone char used in sugar refining, the success of the process depends largely on the efficiency with which the char can be revivified so that it can be used many times. To fill the need for basic knowledge in this field, a research program was initiated in 1939 at the Bureau for study of the fundamental nature of bone char and other solid adsorbents. Today industrial supporters of the work include almost all of the cane sugar refiners and bone char manufacturers of the United States as well as those of many other countries. The purpose of the Technical Session was to inform the industry of the status of the program and to permit informal discussion of problems of mutual interest.

Three special topics were discussed at the Session: Ion exchange reactions, water-washing operations with bone char, and the status of bone char research in progress at NBS. Several general papers were also presented. At a banquet held on Thursday evening, February 26, Professor A. G. Keller of the Louisiana State University spoke on the development of the sugar industry in Louisiana. George P. Meade, manager of the Colonial Sugar Co., was chairman of the Local Arrangements Committee, and V. R. Deitz of NBS headed the Technical Program Committee.

The first morning session dealt with the washing of bone char. J. M. Brown (Revere Sugar Refinery) summarized the char washing procedures in use at the refineries of the sponsors of the Bone Char Research Project. He emphasized the economic savings that his refinery has realized in applying the results of research in char washing. H. I. Knowles (Atlantic Sugar Refineries, Saint John, New Brunswick) discussed continuous versus intermittent washing of bone char filters. The rest of the morning meeting was thrown open to a general discussion of refinery experiences.

The Thursday afternoon session was given over to four general papers. Means for reducing the heat required in the bone char process were described by F. M. Chapman and the technical staff of Tate and

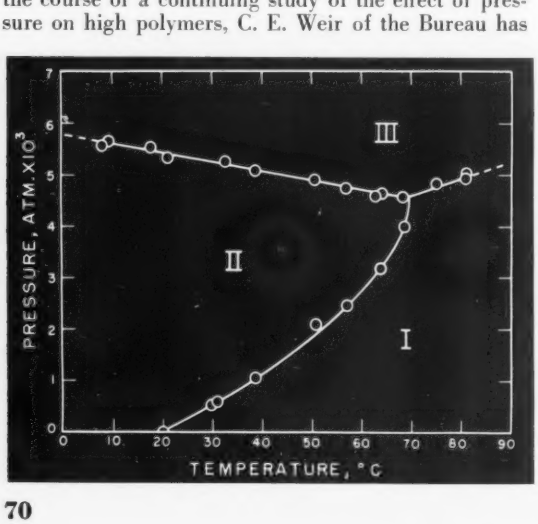
Lyle, Ltd. (London). R. J. G. Macdonald (British Charcoals and Macdonalds, Ltd., Scotland) and H. C. S. deWhalley (Tate and Lyle, Ltd.) discussed the column method for testing the decolorizing power of new and stock chars. R. F. Black and C. W. Beal (California and Hawaiian Sugar Refining Corp., Ltd.) presented a refining scale study of Synthad C–38, a synthetic replacement for bone char. The bone char station at Tirlemont Refinery in Belgium was described by A. Berge and F. Baerts (Tirlemont Refinery).

Ion exchange reactions was the subject of the Friday morning session. W. W. Blankenbach (The British Columbia Sugar Refining Co., Ltd.) discussed a new ion in adsorbing resin that has been developed for the control of iron in sugar products. Soft sugars made from syrups treated with such a resin have excellent bloom and bright colors that are more permanent than can be obtained by any other known means. A comparison of several strongly basic anion-exchanger resins was given by C. A. Fort, B. A. Smith, and L. F. Martin (Southern Regional Research Laboratory). Temporary retention of reducing sugars by this type of anion resin makes possible a fractionation of effluent juices into high- and low-purity products. A process that uses ion exchange resins for the separation of organic acids in juices was described by H. S. Owens, J. B. Stark, and A. E. Goodban (Western Regional Research Laboratory). Kurt Löwy (Companhia Uniao dos Refinadores, Sao Paulo, Brazil) gave the results of a study of ash adsorption by bone char and its desorption by chemical treatment. The desorption of ash improved the ash removal but did not modify the color-removal qualities of the char.

The final session on Friday afternoon was given over to papers in which staff members of the NBS bone-char research laboratory reported on bone-char research in progress at NBS. F. G. Carpenter presented a theoretical expression for the smallest weight of sample that can be used for any test of a granular material and gave applications to several test procedures for bone char. The determination of color removal by char in laboratory test procedures—a difficult problem because of the many variables influencing the test—was discussed by N. L. Pennington with special reference to the measurement of the "color" of the sugar liquor. In a talk on the adsorption wave concept as applied to char columns, W. V. Loebenstein discussed the possibility of deriving a fundamental equation based on theoretical considerations that would predict color removal as a function of flow rate, time, original color, and dimensions of the column. Allen Gee presented a paper on the solubility of basic calcium phosphates. The relation of surface area of the char and the chemical activity of the char surface to decolorizing ability was brought out by H. P. Freeman, and L. P. Domingues discussed the increase in sulfur content of bone char revivified in the presence of sulfur dioxide.

Transitions in Teflon

BECAUSE TEFLON (polytetrafluoroethylene) is highly resistant to chemical and thermal degradation, this plastic is proving very useful in gaskets, washers, valve packings, and similar applications. However, where dimensional stability is required, consideration must be given to the transitions—always accompanied by sharp changes in volume—that occur between different polymorphic forms of this polymeric material with changes in temperature and pressure. In the course of a continuing study of the effect of pressure on high polymers, C. E. Weir of the Bureau has found that Teflon is unique among all high polymers investigated to date in that it exists in three polymorphic forms within the range from 10° to 80° C at pressures between 1 and 10,000 atm. Two different transitions between phases may occur at room temperature, depending on the pressure to which the specimen is subjected.



Phase diagram showing three transition lines determined for Teflon. The transition lines intersect in a triple point, separating the chart into three-pressure-temperature regions; within each region Teflon exists in a different polymorphic form, designated I, II, or III.

The work on Teflon was carried out as part of a broad program of research now under way at NBS on the fundamental properties of high polymers. Polymeric substances—such as rubber, plastics, textiles, leather, and papers—owe their elasticity, plasticity, and other special qualities to the long, chainlike structure of their molecules. The Bureau is investigating the basic constants and properties of these materials in order to learn more about their molecular structure and thus to design new polymers having specified characteristics. A knowledge of the conditions under which transitions take place in high polymers is needed in order to predict the temperature range over which a given polymer will have useful mechanical properties.

In the NBS experiments, the Teflon specimen was immersed at different temperatures in a suitable pressure transmitting liquid within the smooth bore of a thick-walled bomb of hardened steel. Pressure was

applied to the specimen by means of a leak-proof piston forced into the bomb. At intervals the depth of penetration of the piston and the corresponding hydrostatic pressure were measured. When pressure was plotted against piston position (an indication of the extent of volume change), the transitions between polymorphic forms appeared as discontinuities in the curve.

The entire apparatus, including a hydraulic press for the application of pressure, was enclosed in a thermostatically controlled air bath. Temperatures were measured with a calibrated mercury thermometer, which was set in a well in a massive brass block fastened to and in intimate thermal contact with the pressure vessel. Depth of penetration was determined to 0.0001 in. by means of a dial gage mounted on the ram used to drive the piston into the vessel. Internal hydrostatic pressure was measured with a manganin pressure gage, which makes use of the very small change in the resistance of a coil of manganin wire with pressure. To take into account effect due to compression of the confining liquid, the piston and ram, the packing washers, and other parts, as well as distortion in the bore of the bomb, the Bureau performed a comparison experiment in which the specimen was replaced by a steel bar of similar volume.

Teflon "melts" at 330° C, passing from a crystalline to an amorphous phase. Previous investigations at NBS and elsewhere had shown the existence of 2 other transition points at room temperature, 1 occurring under atmospheric pressure, and the other under a pressure of 5,500 atm. The first of these transitions takes place at about 20° C and involves approximately a 1-percent change in volume. Actually, this transition, which is reversible and involves a change in the X-ray diffraction pattern, is not a simple effect but is rather a complex transition appearing to consist of 2 overlapping volume discontinuities, 1 centered at 20° C and the other at 30° C. The second room-temperature transition, at 5,500 atm, takes place at 25.5° C and involves a volume change of about 2.5 percent.

The NBS studies show that on a pressure-temperature chart, or phase diagram, the 2 room-temperature transitions are points on 2 different transition lines which, together with a third transition line, intersect in a triple point and form the boundaries between 3 polymorphic forms of Teflon, designated phases I, II, and III. The room-temperature transition at atmospheric pressure is the beginning of a transition line between phases I and II which proceeds to higher pressure at an accelerating rate with increasing temperature and finally terminates in the triple point at about 70° C. At the higher pressures the volume change associated with this transition line decreases rapidly to a very small value. The transition line between phases II and III leaves the triple point with negative slope, proceeding toward lower temperatures and higher pressures and ultimately passing through the high-pressure room-temperature transition point previously observed at 5,500 atm. The average negative latent heat involved in crossing this transition line has been calculated to be about 29 j/g.

The third transition line, between phases I and III, passes from the triple point to higher pressures with increasing temperatures. Within the region studied, this transition line is also accompanied by a volume change of about 2.5 percent. However, because of experimental limitations this line could not be followed to temperatures higher than 81° C.

A thick-walled steel bomb (left) was used in studies of transitions that occur between different forms of Teflon. Pressure is applied to specimen within bomb by means of a central piston actuated by a hydraulic press. Temperature within the pressure vessel is determined on the glass thermometer (right of bomb) set in a massive brass block in intimate contact with the vessel. Bridge at right measures resistance changes in a manganin pressure gage. Changes in dimension of the specimen are followed on a dial gage (not shown) attached to the ram that drives the piston. The apparatus is enclosed in a temperature-controlled room.

Although certain thermodynamic relationships do not appear to be rigidly fulfilled in the region of the experimental triple point, the discrepancies can probably be ascribed to experimental error and to the fact that the transitions occur over finite intervals of pressure and temperature. Extremely sharp transitions would not be expected inasmuch as Teflon in all probability does not consist of a single molecular species.

For further technical details, see Transitions and phases of Teflon, *by C. E. Weir, J. Research NBS* **50,** *95 (1953), reprinted as NBS Research Paper RP2395, obtainable for 5 cents from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.*

MILITA

An assembled 15-ma, 85-kvp portable field X-ray unit designed for use in military field operations. The equipment has been developed as a result of a long-range program coordinated by NBS for the Army Surgeon General's Office. The unit combines ruggedness and durability with light weight. This portable apparatus may be used for bedside examination or with a lightweight table. The blower-cooled tube head is conservatively rated at 85 kvp and 15 ma for radiography and at 85 kvp and 6 ma for fluoroscopy.

PAST EXPERIENCES in military medicine have revealed a need for light, easily transportable yet reliable X-ray equipment that can provide essentially the same diagnostic facilities in the forward combat areas as are available in base hospitals. As the result of a long-range program coordinated by the National Bureau of Standards for the Army Surgeon General's Office, a lightweight field unit and a standardized hospital unit have been developed that satisfy the requirements of combat operations. The equipment combines ruggedness and durability with light weight and, of great importance, standardized components are used that may be interchanged irrespective of manufacturer. Many of the techniques and component parts are being incorporated into commercial equipment; thus radiologists will experience little difficulty in the transition from civilian to military radiology.

The basic unit developed for mobile field operations is a very lightweight, low-energy (15 ma, 85-kv peak) generator incorporating a two-position radiographic and fluoroscopic table with a Bucky diaphragm (a device for increasing film quality by reducing the effects of secondary radiation from the patient's body). In addition, a motor-driven hydraulically tilted table was designed for use with a higher-energy (100 ma, 100-kv

Complete field X-ray unit and 15-ma, 85-kvp generator packed for shipment. The large container is formed by the top panel and the base of the lightweight table. Inside are packed the tube-head stand, the control unit, and accessory cables and spare parts. This development is the result of a program designed to provide easily transportable yet reliable X-ray equipment that offers the same diagnostic facilities in the forward combat areas as those available in base hospitals.

ILITARY FIELD X-RAY EQUIPMENT

peak) generator of unique design in fixed or rear echelon hospitals. This table has a simplified spot film device and a reciprocating Bucky diaphragm and is used with a floor rail mounted tube stand.

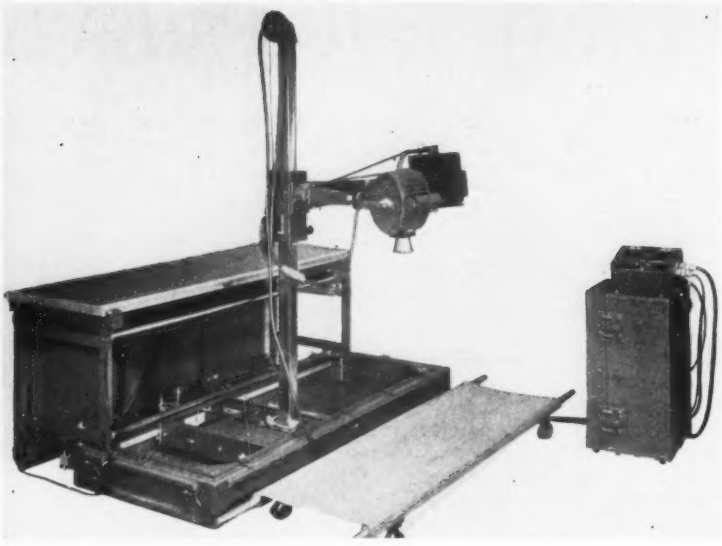
Extensive performance studies carried out by the National Bureau of Standards assure that the various components of all units meet the requirements of both medical treatment and combat service. Special effort was made to achieve simplicity of operation, accessibility of components for servicing, and standardization of replacement parts. Detailed specifications make it possible for a number of different manufacturers to mass-produce any given component with so little deviation as to permit complete interchangeability. Thus, the problem of supplying replacement parts in the field has been greatly simplified. Yet, although many features of the equipment vary considerably from those of conventional commercial units, nothing considered essential for high quality radiography and fluorography has been sacrificed.

To meet the special conditions encountered during military operations, all pieces of equipment are designed to withstand transportation and storage at temperatures between $-50°$ F to $+150°$ F and over a wide range of humidity. Materials are used that will not be impaired by sudden and extreme climatic changes and that can be rust-proofed and treated with an antifungicide. Exceptional rigidity and specially designed packaging afford protection against shock, moisture, and corrosive agents. The X-ray units are further designed to be quickly unpacked, assembled, disassembled, and packed under the most stringent of conditions.

The power circuits are designed to operate with either commercial power, when available, or portable military motor generator sets. Because in field operations the supply of water is often inadequate for conventional X-ray film processing, special processing techniques have been developed that require a minimum quantity of water.

The less mobile radiographic and fluoroscopic units closely resemble large commercial units. Modifications from conventional designs include changes that facilitate shipping, assembly, disassembly, repair, and replacement of worn or damaged parts. Provision is made for both horizontal and vertical radiography, and the tube stand may be rotated to permit stretcher radiography behind the table and the use of the horizontal beam for lateral radiography. Instantaneous spot film radiography, including the use of a compression cone (device to push fat and tissue out of irradiated field), is part of the present design. The table is designed to permit fluoroscopy from 10° Trendelenberg (position in which the patient's head is lower than his feet) to vertical and has a motor drive of sufficient power to angulate the table with the patient in place.

The equipment for mobile field hospitals is lighter and of a more simple design. Some sacrifice of function has been made to achieve mobility; nevertheless, this class of equipment still provides the essential diagnostic procedures. Vertical and horizontal radiographic and fluoroscopic investigations can be made, but no spot film radiographs can be taken. Other components of the mobile unit are a rigid table top, which can be changed from the horizontal to vertical position by hand, and a Bucky diaphragm. Nonstereoscopic and nonbucky chest radiography, and stretcher and



Lightweight military field X-ray unit (rated at 85 kvp and 15 ma) arranged for use in stretcher radiography. The unit may be used for either radiography or fluoroscopy in advanced areas as well as at fixed hospital installations.

lateral radiography can also be performed with this unit.

For highly mobile situations the 15-ma, 85-kvp tube transformer head, control and tube stand, less the field table, may be carried by hand. These lightweight units utilize the newly developed self-processing film packs of the Land-Polaroid type. Because the base of the tube stand for this unit is equipped with casters, it may also be used as a bedside unit in fixed installations.

Mobile Field Unit

The mobile field unit is a low-powered X-ray apparatus sufficiently light to permit hand portability. The yoke of the simplified X-ray tube may be attached to a portable tube stand for use at bedside examination or to a lightweight table. The blower-cooled tube head is conservatively rated at 85 kvp and 15 ma for radiography, and 85 kvp and 6 ma for fluoroscopy. About 2 kva of power is consumed by the complete unit and may be obtained from sources generating 50- or 60-cycle alternating current at 90 to 240 v.

The light, portable tube stand is constructed of a cast aluminum base. It is equipped with large casters and a double-tube column, which supports the hand-cranked elevating mechanism of the tube carriage. This stable column, fixed against rotation at its base, provides sufficient vertical adjustment for alining the tube head under litters and over hospital beds.

The front panel of the lightweight field table is made of rigidized aluminum with a lead covering over the center third of the panel. The base of the table contains a box-shaped section designed to receive the base of the tube stand, which may then be moved in the longitudinal and transverse directions. The table base also serves as the packing chest for components, and the front panel serves as the top of the packing case. The tube column, which may be "broken" in the center, is spring-counterbalanced and supports the tube carriage and the arm of the fluoroscope screen. A pivot arrangement allows the tube unit to be placed under or over the table. The mounting bracket is designed to receive either the 15-ma head or a 100-ma X-ray unit, thus extending the useful range of the lightweight table to include fixed hospital installations as well as the mobile sites.

Additional radiological coverage of a patient is made possible by a plywood panel that slides along the table and effectively adds about 2 ft to the relative movement of the X-ray tube. The panel also tilts into a vertical position at the foot end of the table and acts as a guide during vertical fluoroscopy. The table panels may be removed and a stretcher placed on the frame, or the tube stand may be rotated 180° for stretcher radiography at the rear of the table. A reciprocating Bucky of simplified design and weighing about 20 pounds slides along rails forming part of the table framework.

The construction of this field unit is such that disassembly, assembly, and packing for transportation, can be accomplished in less than 15 min. Special attention has been given to making the unit rugged. Field tests were conducted in which the completely packed table unit was repeatedly dropped from a moving truck. Upon completion of the tests, the unit was assembled and, although not in perfect alinement, it functioned satisfactorily and no parts were found to be broken.

Film processing for the lightweight units has been modified to comply with conditions present in advance military areas. Instead of using conventional developing tanks, the Land-Polaroid process may be applied. The process utilizes special film holders similar in size to the 8- by 10-in. conventional type but adapted to hold a special pack of the Land process type. Following exposure of the film pack, the cassette is placed in an electrically operated processing device that withdraws the pack from the holder, breaks the processing

pod, and distributes the chemical over the film. After 1 min in the developer, the processing device is opened and the radiograph is immediately available for use. At present, the film holder uses paper instead of transparent film; a Land type transparent film, however, is being developed. Although only one intensifying screen is used (as opposed to two in conventional cassettes), the techniques for which this process is useful do not require excessive exposures for readable pictures. The radiograph may be viewed within a few minutes after exposure; and because the usual darkroom facilities are unnecessary, the X-ray unit may be operated in areas where more complete equipment cannot be moved. For extremities and certain other anatomical areas, the Land-Polaroid films produce excellent radiographs.

Standardized Hospital Unit

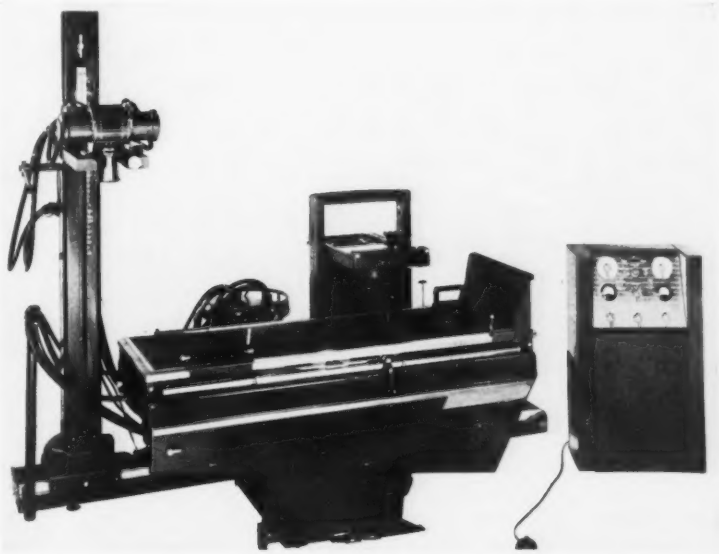
The fixed hospital unit utilizes a 100-ma, 100-kvp X-ray tube designed to operated both with a large tilting table and the lightweight field table. The tube housing is equipped with standardized shockproof cable terminals, thoroughly tested and accepted as Federal Standard and by the Department of Defense. The 100-ma, 100-kvp transformer unit differs from conventional equipment in that it utilizes a gas, sulfur hexafluoride (SF_6), as an insulating medium instead of transformer oil, thus saving about 150 lb in weight. This nonflammable, odorless, nontoxic gas has approximately five times the density of air and has the further advantage that its insulating properties are not greatly affected by slight contamination with air. The gas is used at atmospheric pressure so that the usual problems of high-pressure containers are not encountered.

The four rectifying vacuum tubes used in the transformer are designed for operation in gas and are sufficiently rugged to be left in place during transportation. The transformer, therefore, is ready for immediate operation upon connection to the control and tube units. In case of damage to the vacuum tubes, the transformer can be used with two rectifying tubes for half-wave operation, and without tubes for self-rectification at reduced ratings.

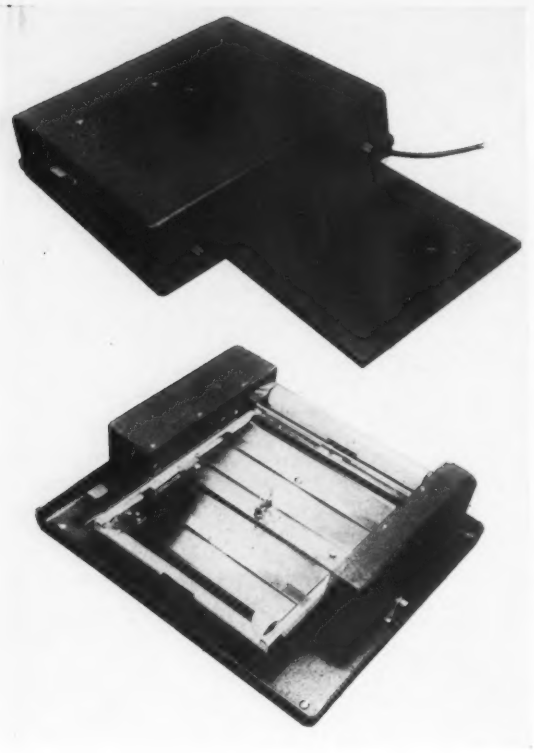
The control unit utilizes aluminum wherever possible to reduce weight. The interconnecting cables, between transformer and control, are equipped with quick-disconnect terminals that can be attached to the control without removing any of its panels. A fluoroscopic timer with a range of up to 5 min, and a synchronous timer, having a range of $\frac{1}{20}$ to 14 sec, are provided. The voltage is adjustable in 2-kv steps from 40 to 100 kv. The technique selector provides for 3 fixed values of current: 100, 50, and 25 ma, and a fluoroscopic position with variable current control.

The hydraulic motor-driven tilt table, which may be arranged for vertical fluoroscopy and spot-film radiography, can be tilted at controlled variable speeds to provide for a range of position from 10° Trendelenburg to vertical. The table is equipped with a reciprocating Bucky diaphragm of the conventional type and a simplified manually operated spot-film tunnel. The floor rail of the tube stand is attached to the table for rigidity, and the tube column is weight-counterbalanced and arranged to rotate about its axis. It is also provided with an automatic stereoscopic shift. Cross-table shift is possible and the tube carriage is arranged so that the tube can be angulated about either of two axes.

Because of the relative permanence of the fixed hospital units, film-processing equipment is necessarily more extensive, although under some conditions it is possible for the field units to utilize the same system. The darkroom is an umbrella type tent, the framework of which folds into a compact unit. It is arranged to accommo-



Hydraulic motor-driven tilt table and 100-ma, 100-kvp X-ray unit designed for fixed military hospitals. This apparatus includes a simplified spot film device and a reciprocating Bucky diaphragm and is used with a floor rail mounted tube stand. As shown, the unit is set up for a fluoroscopic examination. This unit closely resembles large commercial apparatus; and modifications from conventional designs include changes that facilitate shipping, assembly, repair, and replacement of parts. Standardized components that may be interchanged irrespective of manufacture are used. Provision for both horizontal and vertical radiography is made, and the tube stand may be rotated to permit stretcher radiography behind the table.



Land-Polaroid processing unit for rapid development of paper film used in radiographic investigations with a field X-ray unit in combat areas. After the film pack has been exposed, the film holder is placed in the electrically operated processing device (below), which withdraws the pack from the holder, breaks the processing pod, and distributes the chemical over the film.

date two types of coverings, (1) a heavier waterproof covering for film processing, and (2) a lighter opaque canvas cover for fluoroscopy. Sleeves are used to bring electrical circuits, plumbing, and forced ventilating into the tent. Lightweight, light-free storage boxes have been designed that also have sufficient lead shielding to protect the film from stray radiation.

The film-processing equipment consists of a stainless steel tank equipped with two stainless-steel solution tanks and a water conditioning unit. The equipment may be used with or without a pressurized community water source and will circulate a minimum of 60 gal of water per hour. An operating temperature of 68° F for the developer can be reached within 3 hr irrespective of water sources or ambient temperature.

For high portability and use with airborne equipment, a special compact lightweight film processing unit has been proposed. This unit would provide somewhat limited capacity because it would utilize 3-gal instead of 5-gal insert tanks. It would also be somewhat less efficient because circulating cooled or heated air is proposed as the means of conditioning the solutions.

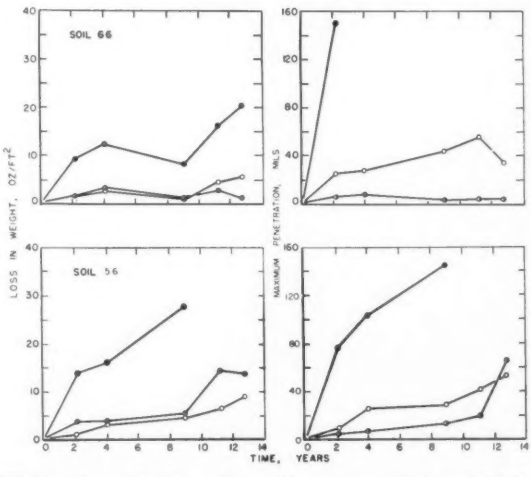
For further technical details see Military field X-ray Equipment, *by H. I. Amory and S. W. Smith, Radiology* **59,** *No. 6, p. 879–892 (December 1952).*

Underground Corrosion of Galvanized Steel

A STUDY of underground corrosion of hot-dipped galvanized steel pipe has recently been completed by NBS. Results confirm previous NBS work in showing that galvanized steel having 3 oz of zinc per square foot of exposed surface is highly resistant to corrosion in many soils which are very corrosive to bare steel. Conducted by Irving A. Denison and Melvin Romanoff of the Bureau's corrosion laboratory, the present study was an outgrowth of earlier NBS exposure tests of zinc coatings for underground use.

For the Bureau's study, short lengths of both galvanized and uncoated steel pipe, and also plates of zinc, were buried at 15 test sites for periods up to 13 years. Located in widely separated parts of the United States, the test sites represented a wide range of soil properties. After each of five periods of exposure a set of specimens of each material was removed and returned to the NBS laboratories. After removal of the corrosion products, determinations were made of loss in weight, depth of the deepest pits, and the percentage of area of the galvanized specimens on which coating remained.

Although the nominal weight of the zinc on all the



Weight loss (left) and maximum penetration (right) curves for specimens exposed to corrosion in two different soils for periods up to 13 years. Solid circles stand for bare steel pipe; open circles, for zinc plate; half-solid circles, for galvanized steel pipe.

Typical specimens of bare steel pipe (top) and galvanized steel pipe (bottom) after 13 years' exposure to corrosion in various soils. Specimens of galvanized steel pipe, bare steel pipe, and zinc were included in the NBS investigation. In many soils, including some in which both zinc and bare steel specimens corroded badly, the galvanized specimens corroded very little.

coated specimens was 3 oz/ft^2, the actual thickness varied over a wide range. This was shown by a large number of thickness measurements made by a magnetic method on unexposed samples of pipe from the same lot as the buried specimens. Additional determinations by an electrolytic stripping method showed that a large part of the zinc that was applied to the steel pipe was converted into alloys of zinc and iron.

The zinc coatings provided good protection in most of the soils. In one soil in which bare steel pipe was perforated by corrosion after exposure for only a few years the coating on the galvanized specimens remained perfectly continuous throughout the entire 13-year period. In only two of the 15 soils, both organic, was the zinc coating of negligible protective value.

An interesting finding of the NBS study was the high corrosion resistance that the galvanized specimens continued to show in most of the soils after the outer zinc coating, and even after the zinc-iron alloy layer, had entirely corroded away. This continuing protection is tentatively attributed to an inorganic coating, probably silicious, believed to have been deposited by galvanic action between the outer zinc coating and the underlying steel or alloy layer. This tentative explanation is based in part on unpublished studies that indicate that the zinc-iron alloy layer does not protect steel sacrificially (cathodically) and that the alloy is no more resistant than steel to soil corrosion.

Analysis of the data obtained in the course of the two NBS field studies shows that the minimum weight of zinc coating required to protect steel for a minimum of 10 years depends on the nature of the soil environment. In the NBS studies a 2-oz coating gave sufficient protection in inorganic oxidizing soils, but for inorganic moderately reducing soils a 3-oz coating was required. Highly reducing soils, both organic and inorganic, make necessary coatings heavier than 3 oz/ft^2.

In order to obtain maximum life from galvanized pipe in practice, it is necessary either to construct the entire piping system of galvanized pipe or else to electrically insulate the galvanized sections from pipe of other metals. Otherwise, the zinc coating will be removed by galvanic action.

For further technical details, see Corrosion of galvanized steel in soils, *by Irving A. Denison and Melvin Romanoff, J. Research NBS* **49**, *299 (Nov. 1952), reprinted as NBS Research Paper 2366, obtainable for 10 cents from Superintendent of Documents, Government Printing Office, Washington 25, D. C. For information on earlier related NBS work, see* Corrosion of metals underground, *NBS Tech. News Bull.* **34**, *48 (April 1950).*

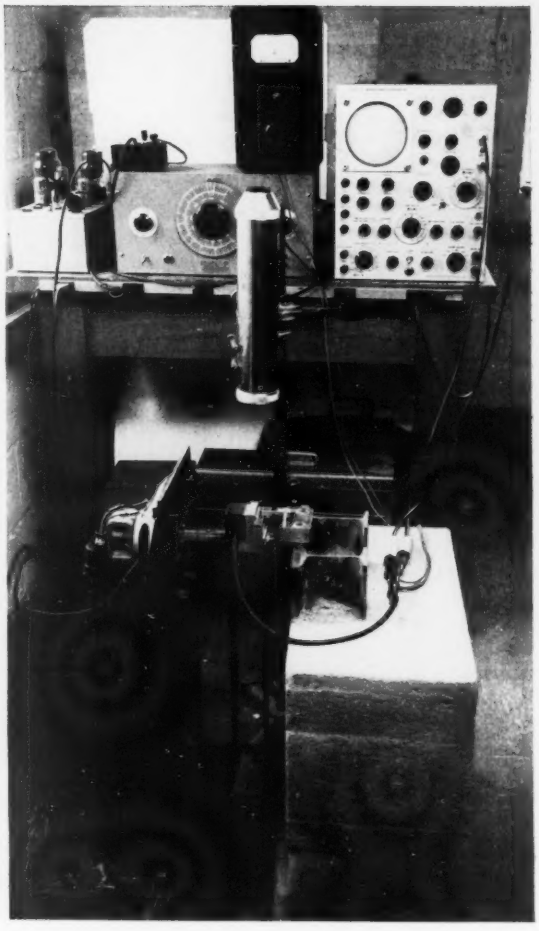
Lightning Protection

In spite of the value of lightning-rod systems for protecting buildings, their use has not proved as effective as possible because of a general lack of information as to the best methods of protection. To enable the public to demand installations designed for adequate protection, NBS has just issued the new edition of *Code for Protection Against Lightning*, sponsored jointly by the National Fire Protection Association, American Institute of Electrical Engineers, and NBS.

The handbook emphasizes personal precautions and protection of buildings and miscellaneous structures. In addition to including material revised from previous handbooks, it contains information on aluminum as a suitable material for lightning protective systems, new rules on grain elevators and on vents and stacks emitting explosive dusts, vapors, or gases, and detailed specifications for lightning rods.

Code for Protection Against Lightning, NBS Handbook 46, may be obtained for 40 cents from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Resonance-Type Vibration Calibrator



NBS vibration calibrator and associated laboratory equipment. Motion of the optical strain gage is observed by means of an autocollimator (cylindrical device which appears in center of photo).

A RESONANCE-TYPE vibration calibrator recently constructed at the Bureau combines unusual simplicity and economy of construction with pure waveform and high sensitivity. The calibrator consists essentially of a system of mechanically resonant beams excited by an ordinary 8-in. loudspeaker; the transducer being calibrated is fastened rigidly to the mechanical system, and the amplitude of vibration is observed optically with reference to a fixed point in space. Designed by Frank C. Smith of the Bureau's sound laboratory, the device has been used to calibrate moving-coil type velocity gages over a frequency range from 10 to 250 cps, at displacement amplitudes of as little as 50 microinch.

Although most vibration pickups are calibrated by the manufacturer, it is often desirable to have available adequate calibration facilities at the laboratory using the pickup. A number of methods of calibrating transducers over various ranges of frequency and amplitude have been developed, but many of these methods require elaborate and expensive equipment. Furthermore, many calibrators are not satisfactory at the small displacement amplitudes at which some sensitive pickups are actually used. Although relatively simple in construction, the NBS equipment can be used to calibrate sensitive transducers at low levels of acceleration, of the order of 0.05 to 5 g.

The resonant beams of the NBS device consist of two parallel plates of high-strength aluminum alloy or medium-carbon steel, each about 18 in. long. The plates used at the Bureau are about 2½ in. in width and range in thickness from $\frac{1}{16}$ to $\frac{1}{4}$ in. By use of various thicknesses and materials, different stiffnesses and thus different resonant frequencies can be obtained. The plates are clamped rigidly to a steel frame at their lower ends and to a block at their free ends; this provides a mass-spring system that produces translatory motion of the clamp block at the free end with negligible rotation, so long as the frequency is below that causing local resonances in the plates. The clamp block serves as the calibration table to which the transducer being calibrated is attached. The motion of the calibration table has no appreciable transverse or torsional components.

The loudspeaker drives the free end of the beams through a thin plastic rod glued to the speaker cone. A conventional audio oscillator and 50-w commercial amplifier drive the speaker. Because of the resonance of the mechanical system only a small amount of power is needed to obtain suitable vibration amplitudes at or near the resonant frequency. Furthermore, electrical wave form is not critical; the resonant system acts as a mechanical filter and gives very pure sinusoidal motion. Because the motion is sinusoidal, peak velocity and acceleration can be easily and accurately calculated from the frequency and the measured displacement.

The displacement of the calibration table is measured relative to a fixed point in space, by means of a Tuckerman optical lever strain gage and an autocollimator. This gage consists essentially of a fixed prism (connected to the reference point) and a small mirror that rotates slightly with motion of the calibration table. By observation of the gage with the autocollimator, dynamic displacements ranging from 5 to 5,000 microinch have been satisfactorily measured. For greater

Close-up of resonance-type vibration calibrator. Although construction is relatively simple and economical, NBS device provides sinusoidal motion and high sensitivity for calibrating vibration pickup. Two parallel metal plates (center) are fastened rigidly at their lower ends to steel frame and are fastened together, separated by combination clamping block and calibration table, at their free ends. An ordinary loudspeaker (left) drives this cantilever-beam spring system. Gage being calibrated is fastened to calibration table. Amplitude of motion is observed in relation to fixed reference point by means of optical strain gage and autocollimator (not shown). So that it will remain motionless, reference point is mounted on massive concrete block. Strain gage is small rectangular device extending from calibration table to reference point.

displacements an inexpensive microscope with a built-in micrometer reticle gives good accuracy. The optical gage method has been used at NBS with apparently good results at frequencies up to 250 cps; the upper frequency limit for satisfactory measurements is believed to be determined by the mechanical inertia of the gage.

With the equipment used at NBS it was found that a single set of beams could be used for a frequency range of about 3 to 1—from about 50 percent to 150 percent of the resonant frequency of the beams. For calibration at frequencies beyond the range of 1 set of beams, the beams must be removed and a different set installed, a procedure requiring about 10 min. Only 3 different pairs of beams are needed to provide a calibration range of 10 to 250 cps.

Care must be taken to insure that the reference point to which the displacement measurements are referred remains motionless. At NBS this was accomplished by making the reference point part of a very heavy and rigid concrete block. An alternative would be to mount the reference point on an elastic system having a very low natural frequency, perhaps one-fifth of the lowest frequency at which calibrations are to be made. Regardless of the method of isolation used, any significant motion of the reference point during a calibration run can be detected by means of a monitoring pickup mounted on the reference-point structure.

Standard Petroluem Measurement Tables

The Bureau has announced that its Circular 410, *National Standard Petroleum Oil Tables*, will be withdrawn from circulation July 1, 1953, unless cogent reasons for retaining the circular are presented by interested parties. The information given in Circular 410 has now been incorporated in the *ASTM-IP Petroleum Measurement Tables* recently issued by the American Society for Testing Materials and the Institute of Petroleum (Great Britain).

The ASTM-IP tables were prepared through close cooperation between the 2 societies over a period of more than 8 years and were developed by committees on which all interested organizations, including NBS, were represented. The new tables constitute a very considerable extension of both Circular 410, issued by NBS in 1936, and the *Tables for Measurement of Oil*, published by the Institute of Petroleum in 1945.

Although the original data on which the two latter tables were based have been recomputed, the common portions of the new and the old tables are numerically identical except for minor changes involved in smoothing and rounding operations. These differences are for the most part only one or two units in the last digit and consequently have little significance for most practical uses to which the tables may be put. Nevertheless, confusion might arise from the use of two sets of tables differing only slightly in numerical values. For this reason, and because of the wider temperature range and larger scope of the new tables, NBS proposes to withdraw its Circular 410. In order that adequate consideration may be given to any reasons that may be advanced for retaining Circular 410, it is requested that such reasons be presented to the Director of the Bureau before June 15, 1953.

The new tables are available from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania. If Circular 410 is withdrawn, all persons requesting copies will be referred to the superseding publication.

TECHNICAL NEWS BULLETIN

U. S. DEPARTMENT OF COMMERCE

SINCLAIR WEEKS, *Secretary*

NATIONAL BUREAU OF STANDARDS

A. V. ASTIN, *Director*

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Publications of the National Bureau of Standards

PERIODICALS

Technical News Bulletin, volume **37,** number 4, April 1953, 10 cents. Annual subscription, $1.00.

CRPL–D104. Basic Radio Propagation Predictions for July 1953. Three months in advance. Issued April 1953, 10 cents. Annual subscription, $1.00.

RESEARCH PAPERS

Reprints from Journal of Research, volume **50,** number 3, March 1953. These reprints may be obtained only in quantities of 100 or more from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Prices will be quoted by the Superintendent of Documents.

RP2399. An intersystem transition in the first spectrum of beryllium. W. R. Bozman, C. H. Corliss, W. F. Meggers, and R. E. Trees.

RP2400. Synthesis of lactose-1-C^{14} and lactobionic-1-C^{14} delta lactone from 3-β-D-galactopyranosyl-α-D-arabinose. Harriet L. Frush and Horace S. Isbell.

RP2401. Surface areas of cottons and modified cottons before and after swelling as determined by nitrogen sorption. Florence H. Forziati, Robert M. Brownell, and Charles M. Hunt.

RP2402. Measurement of multimegohm resistors. Arnold H. Scott.

RP2403. Temperature dependence of compression of natural rubber-sulfur vulcanizates of high sulfur content. Charles E. Weir.

RP2404. On a recursion formula and on some tauberian theorems. N. G. de Bruijn and P. Erdos.

RP2405. Pyrolysis of styrene, acrylate and isoprene polymers in a vacuum. S. Straus and S. L. Madorsky.

RP2406. Tabulation of an integral arising in the theory of cooperative phenomena. Michael Tikson.

BUILDING MATERIALS AND STRUCTURES REPORTS

BMS135. Fire tests of steel columns encased with gypsum lath and plaster. Nolan D. Mitchell and James V. Ryan. 15 cents.

CIRCULARS

C522. Mass spectroscopy in physics research. Proceedings of a symposium held September 6–8, 1951. $1.75.

C536. Radio frequency power measurements. Roald A. Schrack. 15 cents.

HANDBOOKS

H52. Maximum permissible amounts of radioisotopes in the human body and maximum permissible concentrations in air and water. 20 cents.

MISCELLANEOUS PUBLICATIONS

M206. Report of the Thirty-Seventh National Conference on Weights and Measures, 1952. 40 cents.

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On the approximation of linear elliptic differential equations by difference equations with positive coefficients. T. S. Motzkin and W. Wasow. J. Math. and Phys. (Eric Reissner, Massachusetts Institute of Technology, Cambridge 39, Mass.) **31,** No. 4, 253 (January 1953).

Metric methods in integral and differential geometry. Jerry W. Gaddum. Am. J. Math. (Johns Hopkins University Press, Homewood, Baltimore 18, Maryland) **75,** No. 1, 30 (January 1953).

Some relations among the blocks of symmetrical group divisible designs. W. S. Connor. Annals of Math. Statistics (Mt. Royal and Guilford Avenues, Baltimore 2, Maryland) **23,** No. 4, 602 (December 1952).

Two existence theorems for systems of linear inequalities. Leonard M. Blumenthal. Pacific J. Math. (University of California Press, Berkeley 4, California) **2,** No. 4, 523 (December 1952).

Effect of tensile strain at low temperatures on deformation twinning in ingot iron. Glen W. Geil and Nesbit L. Carwile. J. Metals (29 West Thirty-ninth Street, New York 18, N. Y.) **5,** 213 (February 1953); will also appear in Trans. AIME **197,** 213 (1953).

Military field X-ray equipment. Harold I. Amory (Walter Reed Army Hospital) and Scott W. Smith (NBS). Radiology (Donald S. Childs, 713 East Genesee Street, Syracuse 2, N. Y.) **59,** No. 6, 879 (December 1952).

Remarks on some modular identities. Morris Newman. Trans. Amer. Math. Soc. (531 West 116th Street, New York, N. Y.) **73,** No. 2, 313 (September 1952).

Publications for which a price is indicated are available only from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (foreign postage, one-third additional). Reprints from outside journals are not available from the National Bureau of Standards but can often be obtained from the publishers.

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